Academic Statement

> I love him, and only God knows how much.

💡 Two Current Research Lines:

▼ **Exploring the Impact of Data Distribution Properties on Epistemic Model Performance:**

- ▼ **Ultimate Objective:** Attaining a comprehensive understanding of the transitivity between classes' power within the given data distribution.
- ▼ **Current Focus:** Investigating the influence of data trends on the formalization of Neural Collapse.
- ▼ **Methods:** Improved UFM + Adaptive ETF classifier

▼ The difference between data distributions and how it works on the aleatoric model performance

▼ **Ultimate Goal:** Gaining insight into the minimum "information" required from the test data distribution, facilitating the design of effective and desirable techniques.

▼ **Current Focus:** Analysis of the differential privacy + fairness

▼ **Methods:** Information-theoretic techniques

"Deep learning techniques are merely tools; what topic do you intend to investigate, and more importantly, from what perspective or angle?" In the deep learning class I attended, the professor posed this pivotal question: Building upon my strong foundation in this field throughout my undergraduate and particularly through my research on trustworthy AI under the supervision of Prof. Mengnan Du, I can now provide a clear answer: My focus lies in building efficient and trustworthy machine learning, with an approach centered around specifying and leveraging the properties of the data distribution to align data, models, and tasks. Pursuing a Ph.D. would allow me to delve deeper into my research interests and contribute to this field.

Recognizing the Properties of the Data Distribution

To broaden my understanding of efficient machine learning beyond the classroom, I first studied the high-frequency financial market due to its competitiveness and the need for timely responses to various unexpected challenges. The main challenge was designing effective high-frequency trading techniques to achieve excess returns. In 2022, I led a team and conducted extensive data preprocessing, and extracted multiple financial factors to capture the underlying properties of the data distribution. After an extensive literature review, I proposed an innovative approach utilizing shallow and curated LSTM models to enhance accuracy while maintaining computation speed. The results were remarkable, surpassing traditional methods by 1.5%—a noteworthy accomplishment, compared to the 0.5% improvement over existing methods within the high-frequency trading domain. Through this process, I refined my research skills and recognized the substantial impact of the hidden structure of observed data on the efficiency, particularly the model performance, of machine learning techniques. Moreover, I realized the critical role of computation speed in efficiency, prompting my future research focus on this aspect.

To explore the factors affecting computation speed, I researched accelerating the computation speed of an existing framework for skeleton-based human motion quality

assessment. I carried out this research under the supervision of Prof. Yongxiang Li to refine the framework based on the spatial-temporal Graph Convolutional Network. During literature research, I discovered that existing methods, despite stacking multiple layers of LSTM in the temporal domain and employing a large number of parameters, still struggled to effectively extract temporal symmetries in videos. Consequently, I introduced bilateral LSTM with an attention module to reduce the need for stacking extracted representations while maintaining performance. I also identified inefficiencies, such as code redundancy, in the existing codebase. Therefore, I incorporated several acceleration techniques such as matrix acceleration modules to accelerate the process. These efforts successfully led to a 25% increase in training efficiency, reducing batch training time from 60 seconds to 45 seconds. During this journey, my coding skills witnessed substantial growth and again found that the efficiency, including computation speed, relied heavily on the data hidden structure.

Analyzing the Properties of the Data Distribution

To delve into the realm of trustworthy machine learning and explore the intricacies of the data hidden structures, in the summer of 2023, I immersed myself in the study of properties related to trustworthy notions, particularly fairness, under the guidance of Prof. Mengnan Du. To disentangle the data-centric and model-centric views in measuring unfairness, I decomposed the unfairness into data unfairness arising from the data distribution and model unfairness stemming from the choice of models under reasonable assumptions. This approach provided the theoretical insight that the influence of the hidden structure on the trade-off can be partially captured by the optimal decision boundaries of each group. I submitted this work as the first author to ICLR 2024. In this process, I observed that different types of data distributions may exhibit similar behaviors under the same model. Hence, to understand the underlying mechanisms, I investigated the hidden structure of data distributions and its impact on the Neural Collapse. I chose the data trend, which was simple in analysis but common in reality, to examine its impact on model performance. This research is still ongoing and I gradually certify my concentration throughout my research: revealing the properties of the data distribution and aligning the data, the models, and the tasks.

Planning the Graduate Research

Building upon all my research experiences, I am determined to pursue a research career in efficient and trustworthy machine learning, with an approach centered around

specifying and utilizing the properties of the data distribution to align data, models, and tasks. During my graduate, I intend to first investigate transitivity between classes within text data types—a perspective not fully captured by the classic topic model in natural language processing. With this, I aim to enhance the robustness and fairness of language models while maintaining their accuracy. Subsequently, I aim to extend the transitivity to other types of relations and build an analytical framework to formalize the interaction between the data, the models, and the tasks. My ultimate goal is to seek an academic position so I can explore my current and future interests with greater flexibility. Besides, pursuing a Ph.D. would allow me to explore my interests at the highest level. If granted this extraordinary opportunity, I aim to leverage the resources within this department, especially the open environment for academic discussion and the potential of collaborating with experts from different domains, to launch a successful research career of my own.

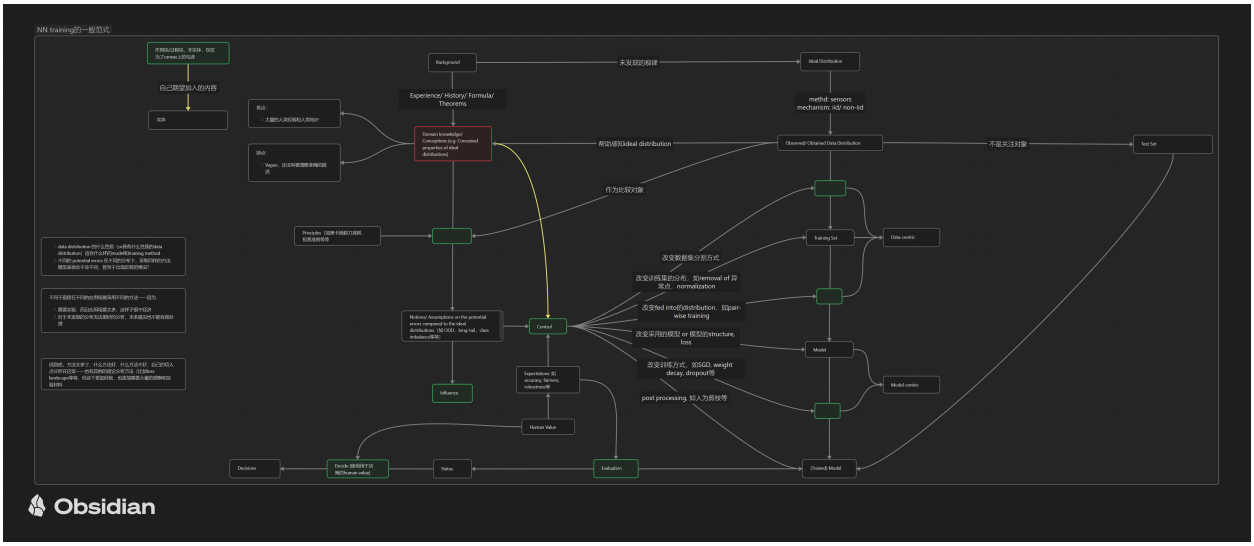

Figure 2: NN training paradigm. The yellow line represents what I aim to do in my future work.

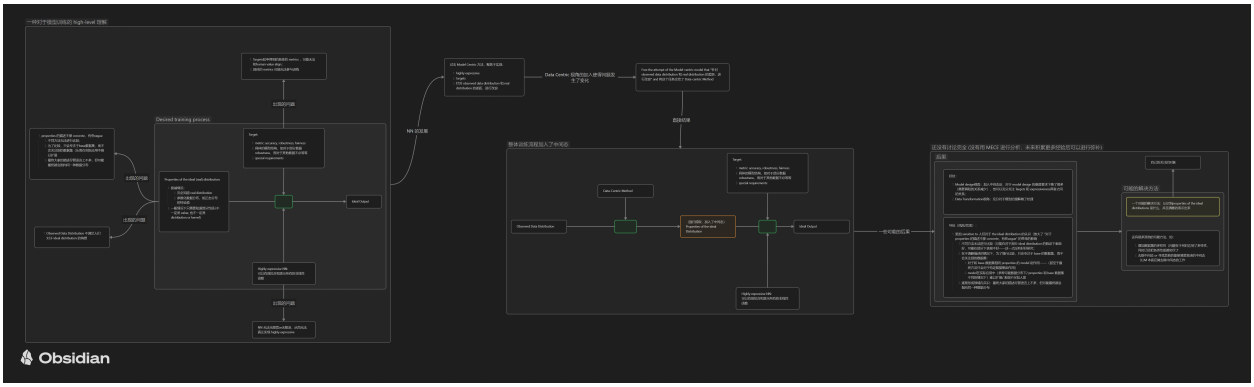

Figure 3: What and Why can and cannot the data-centric methods do: Through the “alignment” lens.